*Global Sustainability*

**cambridge.org/sus**

# Earth stewardship, water resilience, and ethics in the Anthropocene

Jeremy J. Schmidt

Department of Geography, Durham University, Durham DH1 3LE, UK

**Research Article**

**Cite this article:** Schmidt JJ (2023). Earth stewardship, water resilience, and ethics in the Anthropocene. *Global Sustainability* **6**, e15, 1–8. https://doi.org/10.1017/sus.2023.13

Received: 7 March 2022
Revised: 18 June 2023
Accepted: 16 August 2023

**Keywords:**
earth systems (land; water and atmospheric); policies; politics and governance; social value; water security

**Author for correspondence:**
Jeremy Schmidt
Email: jeremy.schmidt@durham.ac.uk

**Non-technical summary.** This article uses water to examine how the relationships of ethics to science are modified through the pursuit of Earth stewardship. Earth stewardship is often defined as the use of science to actively shape social–ecological relations by enhancing resilience. The changing relations of science to values are explored by considering how ideas of resilience operate to translate different ways of knowing water into the framework of Earth stewardship. This is not a neutral process, and Earth stewardship requires careful appraisal to ensure other ways of knowing water are not oppressed.

**Technical summary.** Scientific disclosures of anthropogenic impacts on the Earth system – the Anthropocene – increasingly come with ethical diagnoses for value transformation and, often, Earth stewardship. This article examines the changing relationship of science to values in calls for Earth stewardship with special attention to water resilience. The article begins by situating recent efforts to reconceptualize human–water relations in view of anthropogenic impacts on the global water system. It then traces some of the ways that Earth stewardship has been articulated, especially as a framework supporting the use of science to actively shape social–ecological relations by enhancing resilience. The shift in relations of ethics and science entailed by Earth stewardship is placed in historical context before the issues of water resilience are examined. Resilience, and critiques of it, are then discussed for how they operate to translate different ways of knowing water into the framework of Earth stewardship. The ethical stakes of such translations are a core concern of the conclusion. Rather than reducing different ways of knowing water to those amendable to the framework of Earth stewardship, the article advances a pluralized approach as needed to respect multiple practices for knowing and relating to water – and resilience.

**Social media summary.** Water resilience is key to Earth stewardship; Jeremy Schmidt examines how it changes relations of science and ethics.

## 1. Introduction

Scientific disclosures of anthropogenic forcing on how the Earth system functions, and the stratigraphic signals marking that shift – the Anthropocene – increasingly come with calls for ethical action. Among the most striking was Steffen et al.'s (2018, p. 8258) call for 'deep transformation based on a fundamental reorientation of human values' to shift Earth's trajectory away from a threshold that, if crossed, would result in temperatures above any of the last 1.2 million years. Calls connecting science and ethics are not new. A decade ago, Folke et al. (2011) identified value transformation as key to reconnecting with the biosphere, and numerous calls now position Earth stewardship, or planetary stewardship, as key to the Anthropocene (Rozzi et al., 2015; Steffen et al., 2011). This too is short memory. Holling and Meffe (1996, p. 335) dedicated their riposte against 'command and control' governance to Aldo Leopold, the ecologist and ethicist who 'clearly anticipated' their pursuit of resilience: to enhance the capacity of complex adaptive systems to respond to disturbance. And Worster (1994, p. xi) opened his history of ecological ideas by noting sciences of human–Earth relations have never 'been far removed from the messy, shifting, hurly-burly world of human values'.

Water stands prominently at the intersection of sciences, values, and the Anthropocene. In fact, an important inflection in the history of water sciences and ethics arose with assessments of human impacts on the global water system. These began in earnest after hydrology 'came of age' as a science through UNESCO's *International Hydrological Decade* from 1965 to 1974 (Nace, 1980). Since then, as Schmidt (2017a) details, there has been a veritable cottage industry of studies linking advances in hydrology to normative claims regarding 'water and man' (*sic*). These foreshadowed notions that a collective '*anthropos*' pressured planetary systems in the Anthropocene; a view criticized owing to how it isn't undifferentiated humanity forcing planetary change. Rather, accounts of the intersecting dynamics of colonialism, slavery, racial and gender oppression, Indigenous dispossession, and extractive economies identify both agents and social structures responsible for planetary change (Davis & Todd, 2017; Karera, 2019; Lewis & Maslin, 2018). However, critiques targeting a subset of responsible actors

and 'not all humans' face challenges too given that there aren't singular villains (Sharp, 2020). For instance, Moore's (2015) effort to blame capitalism for planetary malaise – to rebrand Anthropocene as Capitalocene – doesn't capture how state planning in South Asia drove fossil-fuel development (Chatterjee, 2020). Better, then, to recognize how multiple agents and social structures have and continue to generate intersectional inequalities (Tuana, 2019). So too for water. Intersectional injustice abounds in colonial histories of irrigation, infrastructure, and resource extraction as well state-making projects that drained seas and wetlands while building mega dams with reservoirs that affect Earth's rotation and gravitation (Chao, 1995; Peterson, 2019; Ranganathan & Balazs, 2015; Sneddon, 2015).

In the context of historical and on-going inequality, this article focuses on how changing relations of science and ethics situate water resilience with respect to Earth stewardship. That there has been a change is clear: Ripl (2003) argued water's physical, chemical, biological, and energetic characteristics made it the 'bloodstream of the biosphere'. Vörösmarty et al. (2013) catalogued how human impacts on the Earth system reshape empirical accounts of water dynamics and the concepts needed to explain them (cf. Milly et al., 2008; Savenije et al., 2014). Rockström et al. (2014) called for a new politics of water resilience to square hydrology with water's global value to planetary systems. Falkenmark et al. (2019) warned water resilience is needed to avoid social collapse and Gleeson et al.'s (2020) quantification of a planetary water boundary was positioned ethically. Jenkins et al. (2021) compared planetary assessments of water security under plural value frameworks, and Ahlström et al. (2021) argued ethics were pivotal to connecting socio-hydrology to Earth system law.

The above list doesn't exhaust how scholars have sought to rethink relations of water sciences and ethics under conditions of planetary stress. It does, however, highlight the moving target of this article: the use of resilience to translate multiple knowledge practices into the framework of Earth stewardship. The target is 'moving' in the sense that none of science, values, or ethics operates in the Anthropocene as a fixed point of reference against which to gauge movements in other areas of praxis. I make no ambition to artificially tidy things up by pinning them down. Instead, I follow Stengers's (2010) insights regarding how knowledge is connected to the ethos in which it is produced – what she termed an ecology of practices. Stengers (2005, p. 186) developed her view by studying how scientists 'have learned to think in the presence of ongoing facts of destruction' and irreparable harm to the nonhuman world. Although her target was species loss, Stengers's work helps to situate how new vocabularies and conceptual tools seek to reckon human impacts on the global water system with ethical values. Among these, Earth stewardship presents a key site for rethinking relations of science, ethics, and resilience. Chapin et al. (2011a, original emphasis) defined Earth stewardship precisely in response to 'planetary degradation' and enrolled sustainability sciences to actively shape '*trajectories of change in coupled social–ecological systems at local-to-global scales to enhance ecosystem resilience and promote human well-being*'.

Stengers's approach is reminiscent of Bateson's (2000) argument regarding how to understand different ways of thinking on their own terms. Bateson's thought experiment asked where, supposing he was blind and using a walking stick, we could say that *he*, the thinking self, started. Where his hand gripped the stick? Where the stick met the ground? Midpoint on the stick? Bateson's answered such questions were nonsense – mind doesn't have a metaphysical address. Rather, the stick was a pathway along which informational differences were transmitted. For Bateson (2000, p. 465), understanding different ways of knowing required one to 'delineate the system…in such a way that you do not cut any of these pathways [of explanation] in ways which leave things inexplicable'. That is, it was the person-hand-stick-ground system that mattered, none of which could be isolated without severing – making inexplicable – the pathway of knowing. Bateson (2000, p. 466) put it generally by arguing that explaining the coevolution of thought required treating the 'body-in-the-environment'. In short: an ecology of mind.

Bateson's central insight was that relations nest in systems. The idea remains salient given contemporary emphasis on 'thinking in systems' to navigate Anthropocene challenges (Dryzek & Pickering, 2019). Yet it is also troubled by how planetary changes alter the context of learning about systemic feedbacks (Schill et al., 2019; Schmidt, 2017b). Earth stewardship faces similar challenges given the important role of learning for 'science that facilitates the active shaping of trajectories of social–ecological change to enhance ecosystem resilience and human well-being' (Chapin et al., 2011b, p. 3). Plummer et al. (2020) are explicit that directing trajectories of social–ecological systems requires an integrative framework linking science, governance, and social learning (cf. Bennett et al., 2018). There are also ethical challenges. As Schmidt (2022) shows in an analysis of the UN's program on Earth jurisprudence, anchoring relations in a systems view can oppress other pathways of understanding relations, such as through Indigenous kinship. In this context, it is important to examine how, and with what effects, Earth stewardship seeks to actively arrange science and values to retain multiple future pathways of knowing and relating to water.

Using water, this article argues that resilience has become a tool not for isolating different pathways of knowing, but for translating multiple pathways into the framework of Earth stewardship. This raises unique ethical concerns for understanding different future trajectories given water's permeating role in social worlds and biophysical processes. I make this argument in three steps. Section 2 considers how Earth stewardship orients itself to previous scientific initiatives and calls for science to meet the moral duties entailed by specialized knowledge. Section 3 examines critiques of resilience to draw out its ethical stakes so that, in Section 4, the focus can turn to ethically engaging the work of translation that water resilience accomplishes. Section 4 also consolidates a thread that runs through the article regarding ways of knowing and relating to water which may be oppressed through uses of western sciences that delimit trajectories of social–ecological change. Other ecologies of practices, especially by communities violently forced to learn and adapt under conditions of irreparable loss, predate the Anthropocene and are crucial to ethics within it. Yet, understanding functional changes to the Earth system also cannot do without the sciences that disclose planetary changes. What is at stake in the value transformations called for by Earth stewardship and the sciences that animate it, then, is the translation of different pathways for knowing and relating into its framework. These concerns occupy my focus even as other issues are not directly considered, such as the stewardship of collective global behavior (see Bak-Coleman et al., 2021).

## 2. Earth stewardship

Scientific disclosures of planetary challenges have ethical dimensions. For instance, Oreskes (2020) describes the 'duty to warn'

https://doi.org/10.1017/sus.2023.13 Published online by Cambridge University Press

that arises from specialist knowledge that obliges climate scientists to articulate otherwise unknowable risks. It isn't all smooth sailing. Social pressures within scientific communities can inhibit value discussions owing to concerns regarding objectivity (Oppenheimer et al., 2019). In other words, the ethos of scientific praxis bears on the relations of science, ethics, and values. This ethos is part of what made Lubchenco's (1998) call for a new social contract for science a powerful statement at the turn of the millennium. Importantly, Lubchenco's call emerged from an ecology of practices oriented to stewardship: the Ecological Society of America's Sustainable Biosphere Initiative (Lubchenco et al., 1991). That earlier initiative also provided a reference point for Chapin et al.'s (2011a) arguments for Earth stewardship. So too did avoiding what Hardin (1968) termed the tragedy of the commons, which was to be achieved through 'effective management by an informed and interactive community' that constituted 'the ideal that forms part of the foundation of Earth Stewardship' (Chapin et al., 2011a, p. 46). This section examines this ideal in terms of changing relations of science and ethics.

Rozzi et al. (2015) situate Earth stewardship at the intersection of two gaps: geographical gaps in coverage of social–ecological systems by long-term environmental research networks and gaps among those networks on matters of epistemology, politics, and ethics. These 'gaps' present divergent ecologies of practices – networks of knowledge production that attend to different matters of concern (Stengers, 2011). However, 'gaps' in dominant knowledge frameworks often indicate failures to appreciate other forms of expertise, such as Indigenous sciences (Liboiron, 2021). Further, scientific resources often reflect colonial power relations, such as global plant specimens overwhelmingly located in colonial collections and not local herbariums (Park et al., 2023). Moreover, 'gaps' are not neutral. For instance, sampling biases in biodiversity sciences issue from colonial and economic histories that obscure understandings of deep-time changes to the biosphere (Raja et al., 2022). Other challenges arise within scientific networks. For instance, incorporating ecology into scientific programs like the International Geosphere–Biosphere Program (IGBP) faced hurdles owing to the specificity of ecological knowledge in contrast to the 'global' scale required to treat Earth as a single, integrated system (Kwa, 2005). These limits, occlusions, and oppressive practices demand attention. They also make Chapin et al.'s (2011a, 2011b) definitions of Earth stewardship provocative because it uses science to actively shape trajectories of social–ecological systems across scales.

This emphasis on 'active science' – sciences that actively seek to shape the trajectories of social–ecological relations – lies adjacent to the 'use inspired' sciences that Lubchenco and Rapley (2020, p. 3) identify as driven by the pursuit of 'fundamental knowledge to solve problems that are immediately relevant to societal needs'. Although distinct, both reflect important shifts. First, in the history of how scientific objectivity has evolved (Daston & Galison, 2010; Porter, 1995), they exchange dispositions toward science as value-neutral for actively aligning science and values. This is more than a *prima facie* shift given how Cold War geopolitics shaped objectivity in the international networks that anticipated Earth system science (Reisch, 2005; Wolfe, 2018). For instance, the Cold War shaped how contemporary notions of 'systems thinking' developed through scientific collaborations at the International Institute for Applied Systems Analysis (IIASA), which became a blueprint for the IGBP. Like objectivity, thinking in systems has a longer scientific and philosophical tenure (Midgley, 2003; Siskin, 2016). A key part of that story for Earth system sciences is how, at the IIASA, contemporary notions of 'systems thinking' incorporated cybernetics and ecology into a powerful framework for disclosing planetary phenomena (Duller, 2016; Rindzevičiūtė, 2016). It was the IIASA, for instance, that published the landmark work *Sustainable Development of the Biosphere* in which Crutzen and others outlined key concerns regarding human–Earth relations, and where Holling expanded ideas of ecological resilience through the notions of thresholds and tipping points (Clark & Munn, 1986). The launch of the IGBP in 1987 was a fillip for Earth system science, especially when the end of the Cold War expedited knowledge transfer in international networks (Uhrqvist & Lövbrand, 2014). These histories matter because the sciences employed to actively shape social–ecological trajectories don't operate at remove from their social and political contexts; those contexts are influential in ways recognized by scientific networks themselves (see Seitzinger et al., 2015).

Another aspect of Earth stewardship is avoiding Hardin's tragedy of the commons. There is a large literature modifying Hardin's inadequate account of the commons. Often overlooked, however, are the ethical deficiencies in his account, particularly his derivation of moral 'oughts' from facts about what is – what philosophers call the naturalistic fallacy. Moore (1922) argued this fallacy arises when what is morally good is defined in terms of the properties of what is being described. A clear example besets Hardin's 1968 essay. There, alongside his xenophobia and stance against human rights (Janssen et al., 2019), Hardin (1968, p. 1245, original emphasis) states: '*the morality of an act is a function of the state of the system at the time it is performed*'. Here, Hardin conflates the state of the system with whether an act is ethical or not. Two problems arise. First, Hardin assumes the state of a system could be sufficiently known to make these such judgments. This doesn't hold given the uncertainty and partial perspectives characteristic of scientific accounts. Kay (2000) incisively showed how uncertainty and complexity positions scientists as narrators that connect what is disclosed by complexity sciences to the 'trade-offs' and alternate futures different actions entail.

A second concern with evoking Hardin is that resilience is not the 'state' of a system; it is a way of disclosing capacities to respond to disturbance. For instance, in Steffen et al.'s (2018) account of 'hothouse Earth' the current social–ecological system is near the edge of its capacity to adapt to increased greenhouse gases. Connolly (2013) flips the idea around to consider how the political and economic systems driving planetary forcing are resilient in a way capacious enough to keep them in place despite the harms they generate. These different uses of resilience turn on different ecologies of practice that affect what scientists and political theorists, respectively, pay attention to. Resilience can also be used to describe ethical affordances. Homer-Dixon et al. (2015) describe these as the 'coping capacity' of actors to respond to stress and crises. Here, specialized knowledge of Earth system science anchors a capacity – recall Oreskes's duty to warn – connecting value transformations to shifts in human–Earth relationships that seek to maintain the 'resilience of the Earth system or large portions of it' (Steffen et al., 2011, p. 748).

Does Earth stewardship's effort to maintain planetary resilience commit the naturalistic fallacy by assuming Holocene conditions provide for 'the good' while others, such as Anthropocene conditions, on balance will not? This question lies at the heart of debates over a 'good Anthropocene' versus one destined for planetary denudation. As Daston (2014) shows, several potential

https://doi.org/10.1017/sus.2023.13 Published online by Cambridge University Press

responses reveal how the naturalistic fallacy carries its own history of modernist distinctions among facts, values, and 'nature'. Osorio (2017), for instance, rejects Moore's argument that the naturalistic fallacy is a logical error and argues that sciences, including those of resilience, make both descriptive and evaluative propositions. This bears resemblance to Norton's (2005) account of how resilience, and adaptive management, orient social learning to the science and ethics of complex systems. Norton, following Williams (1985), rejects the fact-value distinction – the bugbear at the heart of deriving any 'ought' from facts about what is – since it depends on applying some specialized theory to parse overlapping aspects of ordinary language and scientific explanations. So, there are defensible positions for Earth stewardship that link resilience to values, but treating Hardin as an ideal isn't among them.

Understanding resilience in terms of ethical affordances positions Earth sciences in key roles when possibilities for value transformation are narrated in response to crises (Folke et al., 2010). Increasingly, the language of 'transformation' operates as the point of conjuncture linking sustainability sciences to the normative and policy ethos of Earth stewardship (Chapin et al., 2022). In Earth stewardship, the possibilities for transformation are informed by and often grounded through Earth system sciences, but nevertheless depend on social values. To paraphrase Bateson, these values do not come from without, but reflect societies-in-Anthropocene environments. In the case of water, accounts of these values highlight their coevolution with hydrological systems now under immense anthropogenic pressure (Falkenmark & Folke, 2002; Vörösmarty et al., 2015; Wang-Erlandsson et al., 2022). The normative upshot is that water's limiting role for social–ecological systems and processes become what Boltz et al. (2019) term a 'master variable' in determinations of how to achieve water resilience in the Anthropocene. Critically, however, the values that could be said to have 'coevolved' with water are manifold, plural, and not always commensurate with one another – many have been explicitly oppressed (Schmidt, 2023). That only some values guide narratives linking uncertainties, crises, and trade-offs is a challenge not because ethics derive from the 'state of the system'. Rather, it is because the ethical affordances of Earth stewardship are scoped to those values that are commensurate with the sciences through which it seeks to actively shape the trajectory of the Earth system.

Finally, Earth stewardship counters a virtual axiom of Anthropocene theorists who interpret the epoch in terms of incommensurability between accounts of anthropogenic impacts on the planet and existing normative resources. Hamilton et al. (2015) argued there is nothing in the evolutionary or cultural heritage of humankind to deal ethically with the scale of the Anthropocene. Chakrabarty (2009, p. 221, original emphasis) claims climate change presents a universal challenge to the condition of human life yet asserts that 'we can never *understand* this universal'. These concerns recall Kuhn's (1996) argument regarding the incommensurability of scientific paradigms. Yet claims of incommensurability in the Anthropocene are difficult to defend because they make one socially situated notion of time the scale for all humanity (Coen, 2016). As I've shown elsewhere, incommensurability is also inadequate owing to how geological reasoning made commensurate early 20th-century hydrology, social sciences, and forms of water management that treat water as a resource (Schmidt, 2017a) – a view still at the normative center of global water governance.

Depictions of the 'human' in Earth system science, and hence of Earth stewardship, insufficiently reflect the diverse ways of knowing and relating to the planet (Castree, 2017; Lövbrand et al., 2015). Further, the Christian heritage of Earth 'stewardship' is often noted (Chapin, 2020; Rozzi et al., 2015; West et al., 2018) yet tends to be quickly scrolled past even though Eurocentric forms of 'stewardship' animated colonial and settler-colonial environmental practices (Stoll, 2015). Failing to account for gendered, racialized, ethnic, caste, class, and colonial oppression is worsened by not reckoning with the diverse and plural actors, relations, and futures of communities for whom environmental apocalypse is already lived reality (Davis & Todd, 2017; Ghosh, 2016). Purifoy (2021, p. 830) argues, for instance, 'Black places are the parables that anticipated climate change, which now threatens the total ecosystem of the Earth and our collective ability to live on it'. Norms and practices sustained by communities long-forced to environmental margins present important alternative pathways that Earth stewardship must not make inexplicable through the 'active sciences' it enrolls.

## 3. Water, resilience, and critique

Resilience has many meanings in ordinary language, and in technical conceptualizations of social–ecological and hydrological sciences (Falkenmark et al., 2019; Folke, 2003). It is a concept widely yet inconsistently used in water policy, where meanings often split across notions of planning and engineering versus the integrated dynamics of social–ecological systems (Rodina, 2019). In this section, I'm concerned with social–ecological approaches to resilience, especially two critiques that cannot be dismissed in Earth stewardship proposals owing to the central role of water in proposals to actively shape Earth's trajectory. The ethical stakes are high; water injustices affecting Black, Indigenous, and other oppressed communities span the Global South and the Global North (e.g. Curley, 2019; Pauli, 2019; Ranganathan & Balazs, 2015).

One critique of resilience identifies its scientific ethos with neoliberalism and the steady creep of capitalist logics into explanations of social and ecological relations (cf. Brown, 2015). Walker and Cooper (2011), for instance, argue that Holling's ecological critique of command-and-control governance finds a strong counterpart in Friedrich Hayek's neoliberal critique of the state. Both Holling and Hayek, for instance, mobilize complexity sciences to argue that the state has insufficient knowledge to plan or manage complex systems. Further, on this critique, Holling's (2001, p. 394) description of resilience as 'accumulated ecological, economic, social and cultural capital' was one metaphor too far in tipping resilience towards a neoliberal ethos in which all relations are rendered in economic terms. Over time, critics argue, a conceptual alliance of resilience with neoliberal critiques of the state transformed the concept from its original, critical orientation to collusion with prevailing power structures. Cooper (2011), for instance, argues that resilience gained enhanced prominence after the 2008 financial crisis owing to its capacity to order economic and ecological crises in ways that would maintain the status quo of capital accumulation. There are ready examples in the water sector; Schmidt and Matthews (2018) tracked how networks of global financial actors, like the World Economic Forum, directly influenced the conjunctive rise of economic tropes, resilience, and 'systems thinking' in water security discourse.

A second critique argues resilience is inherently conservative. Mackinnon and Derickson (2013, p. 254) claim resilience intrinsically 'privileges established social structures' that are often

https://doi.org/10.1017/sus.2023.13 Published online by Cambridge University Press

products and producers of inequality. Largely in agreement with Connolly's (2013) diagnosis (see above), they argue capitalism operates by producing inequality and so aligning resilience with its economic logics conserves those forms of inequality (cf. Piketty, 2017). Others make similar critiques. Nadasdy (2007, p. 215) argues that ecologists and theorists 'necessarily valorize one particular set of social–ecological relations' when they laud resilience. This comes at the expense of asking what kind of resilience should be sought and for whom. Nadasdy's (2007) target is the pursuit of resilient agricultural landscapes that are themselves premised on Indigenous dispossession. In such cases, the choice of which relations matter in a social–ecological system is also an ethical choice of *whose* relations matter. Similar concerns hold for racialized assumptions by colonialists and early 20th-century scientists who blamed desertification in the Sahel on local African communities in ways that continue to influence narratives of desertification in climate change policies at the expense of understanding local, Black practices of resilience (Benjaminsen & Hiernaux, 2019; Meché, 2022).

The critiques above overlap in arguing that resilience is not neutral. It isn't new to note the partiality of knowledge, but it is important to note that how partiality is addressed can come at a cost to particular ways of knowing. Indigenous sciences, for instance, are empirical in ways that do not reduce ecological relations to impersonal causes that characterize the feedback loops of complex systems. Rather, Indigenous sciences explain relations to nonhuman species and processes through kinship (Kimmerer, 2013; Scott, 1996). This includes reciprocal relations and obligations to rivers, lakes, and glaciers (Cruikshank, 2005; Daigle, 2018; Leonard et al., 2023; Wilson and Inkster, 2018). To riff on Bateson's phrasing of a body-in-the-environment, Indigenous peoples have different ecologies of practices through which knowledge and ethos co-constitute accounts of kinship-with-their-relations. Moreover, it is not sufficient to defend resilience by claiming it can form the basis for Earth stewardship to the extent that it aligns with Indigenous understandings because that is not what Earth stewardship claims to be doing in claims to use science to actively shape social–ecological trajectories. Rather, something more striking is afoot: Earth stewardship deploys resilience not to isolate elements in different knowledge pathways, but to translate them into its own ecology of practices.

## 4. Earth stewardship and water resilience

Earth stewardship is an ecology of practices in which science actively shapes planetary trajectories to achieve resilience. The values it draws on are neither complete nor uniform but patchwork (Bennett et al., 2021; Leach et al., 2018). Within Earth stewardship, resilience functions not to isolate different pathways of knowing, but to translate multiple pathways into its own framework. Owing to water's role in multiple Earth system processes, the shift in the relation of ethics and science entailed by Earth stewardship directly affects water resilience in the Anthropocene. It reveals the limits of the 'impair-then-repair' ethos through which 20th-century management practices created unethical impacts on societies at the scale of the global water system (Vörösmarty et al., 2015). As one further example, so much groundwater was pumped between 1993 and 2010 that it tilted Earth's pole nearly 80 cm (Seo et al., 2023). Additionally, the 'active science' of Earth stewardship mobilizes the specialized knowledge of hydrologists and Earth system scientists to address otherwise unknowable, planetary risks. Those sciences cannot be done without in efforts to understand planetary challenges since they are the very means of disclosing them. But Earth stewardship does not stop there; it must also appraise different future trajectories. This raises the question: *Earth stewardship – water resilience – for whose future?*

Earth stewardship took shape around degradation to the nonhuman world, as have new scientific tools and vocabularies seeking to address anthropogenic impacts on the global water system. But other pathways have also emerged. Water scholars describe these in terms Bateson would have approved of: "'river-as-ecosociety", "river-as-territory", "river-as-subject", and "river-as-movement"' (Boelens et al., 2023, p. 1). Importantly, these pathways are often anchored in epistemological, ethical, and ontological orientations to water that entail distinct social worlds (Yates et al., 2017). For instance, relating to water as kin entails a different world of praxis than does systems thinking. In this context, the pursuit of water resilience raises new ethical concerns. To paraphrase Bateson, the nonsense question would be to isolate where ethical changes across different ways of knowing arise: With water users? Where infrastructure meets hydrology? With different governance practices? Rather, what needs to be examined is the role of resilience in translating different pathways of knowing water into Earth stewardship's framework.

Translation is no simple affair. Quine (1960) argued translation was beset by indeterminacy owing to how social and physical phenomena exceed techniques of observing and knowing them. Quine's (1987) influential thesis didn't reject the fact of translation but highlighted how indeterminacy meant that multiple translations of phenomena are always possible. Importantly, Quine focused on radical cases where translation couldn't rely on mediators with even partial knowledge. Indeterminacy arose not because translations are impossible – indeterminacy was not necessarily incommensurability – but because multiple translations could fit the facts and there was no way to settle disputes between competing interpretations (cf. Sankey, 1993). Quine's philosophical inquiry presents a hard case not too distant from debates among social scientists about different ontological worlds and ways of knowing (see de la Cadena & Blaser, 2018). For instance, harms from water pollution can affect Indigenous communities in ways unknowable to others owing to the specificity of relations among place, water, and knowledge (Dotson & Whyte, 2013). In other cases, Indigenous sciences orient knowledge, obligations, and relations towards the pursuit of specific futures (Daigle, 2018; Leonard et al., 2023; Todd, 2017; Watt-Cloutier, 2018). These are nontrivial concerns because the norms and practices of communities long forced to environmental margins matter for just trajectories and futures. Further, what counts as a viable future under climate change scenarios is not an objective exercise but one that actively co-produces value judgments in the language of trade-offs (Poprocki, 2022). Likewise for water resilience, which must translate ecological and relational practices across social worlds if their futures are to be considered candidates for applying the kinds of active science pursued by Earth stewardship.

Mobilizing resilience to translate multiple ecologies of practice into the framework of Earth stewardship, however, runs counter to the ethics of retaining the explicability of different pathways of knowing on their own terms. Indeed, the social science corollary to scientific practices that respond to environmental degradation is to identify how alternate narratives and relations to water make visible what formerly went unconsidered. In the context of Earth stewardship, this means rejecting *ex ante* uses of Earth

https://doi.org/10.1017/sus.2023.13 Published online by Cambridge University Press

system sciences that premediate the spectrum of values for scoping future trajectories. The challenge for Earth stewardship is that *ex post* explanations cannot be guaranteed either owing to how the Anthropocene complicates social learning (Schill et al., 2019; Schmidt, 2017b). What then for water resilience?

Meisch (2019) argues that a narrative ethic for water departs from abstract theorizing to focus on the combination of experience with judgments that depend on lives lived with water. This view places a special burden on ethics not to translate concrete relations with water into abstract concepts. It also leaves room for how water resilience might provide a scientific ethos in which knowledge of water is connected to the Earth system. But narratives are not neutral either: the colonial narratives that filled gaps in early sediment science fostered laws in the Bengal Delta that reverberate inequalities into the present (Bhattacharyya, 2021); telling the story of phosphorous in relation to water, planetary processes, or Indigenous dispossession draws out different moral concerns (Elser & Haygarth, 2021; Teaiwa, 2014). Acts of translation, then, do not reduce in a tidy way to the framework of Earth stewardship. Instead of unproblematic translation there is a need to articulate an ethic in which specialized knowledges of water risks arise from plural ecologies of practice and combine in a duty of care and reparation.

**Acknowledgments.** I am very thankful for the absorbing, thoughtful criticisms of the reviewers on previous drafts. My thanks also go to the special issue editors and participants in the workshop where ideas at the heart of the article were initially presented.

**Competing interests.** None.

## References

Ahlström, H., Hileman, J., Wang-Erlandsson, L., Mancilla García, M., Moore, M.-L., Johas, K., Pranindita, A., Kuiper, J., Fetzer, I., Jaramillo, F., & Svedin, U. (2021). An Earth system law perspective on governing social–hydrological systems in the Anthropocene. *Earth System Governance*, *10*, 100120.

Bak-Coleman, J., Alfano, M., Barfuss, W., Bergstrom, C., Ceneno, M., Couzin, I., Donges, J., Galesic, M., Gersick, A., Jacquet, J., Kao, A., Moran, R., Romanczuk, P., Rubenstein, D., Tombak, K., van Bavel, J., & Weber, E. (2021). Stewardship of global collective behavior. *Proceedings of the National Academy of Sciences*, *118*, e2025764118.

Bateson, G. (2000). *Steps to an ecology of mind*. University of Chicago Press.

Benjaminsen, T. A., & Hiernaux, P. (2019). From desiccation to global climate change: A history of the desertification narrative in the West African Sahel, 1900–2018. *Global Environment*, *12*(1), 206–223.

Bennett, E. M., Biggs, R., Peterson, G., & Gordon, L. (2021). Patchwork Earth: Navigating pathways to just, thriving, and sustainable futures. *One Earth*, *4* (2), 172–176.

Bennett, N. J., Whitty, T., Finkbeiner, E., Pittman, J., Bassett, H., Gelcich, S., & Allison, E. (2018). Environmental stewardship: A conceptual review and analytical framework. *Environmental Management*, *61*, 597–614.

Bhattacharyya, D. (2021). A river is not a pendulum: Sediments of science in the world of tides. *Isis*, *112*(1), 141–149.

Boelens, R., Escobar, A., Bakker, K., Hommes, L., Swyngedouw, E., Hogenboom, B., Huijbens, E., Jackson, S., Vos, J., Harris, L., Joy, K. J., Castro, F., Duarte-Abadía, B., Souza, D., Lotz-Sisitka, H., Hernández-Mora, N., Martínez-Alier, J., Roca-Servat, D., Perreault, T., … Wantzen, K. (2023). Riverhood: Political ecologies or socionature commoning and translocal struggles for water justice. *The Journal of Peasant Studies*, *50*(3), 1125–1156.

Boltz, F., Poff, N. L., Folke, C., Kete, N., Brown, C., Freeman, S., Matthews, J., Martinez, A., & Rockström, J. (2019). Water is a master variable: Solving for resilience in the modern era. *Water Security*, *8*(1–7), 100048.

Brown, W. (2015). *Undoing the demos: Neoliberalism's stealth revolution*. Zone Books.

Castree, N. (2017). Speaking for the 'people disciplines': Global change science and its human dimensions. *The Anthropocene Review*, *4*(3), 160–182.

Chakrabarty, D. (2009). The climate of history: Four theses. *Critical Inquiry*, *35* (2), 197–222.

Chao, B. F. (1995). Anthropogenic impact on global geodynamics due to reservoir water impoundment. *Geophysical Research Letters*, *22*(24), 3529–3532.

Chapin III, F. S. (2020). *Grassroots stewardship: Sustainability within our reach*. Oxford University Press.

Chapin III, F. S., Pickett, S., Power, M., Jackson, R. B., Carter, D., & Duke, C. (2011a). Earth stewardship: A strategy for social–ecological transformation to reverse planetary degradation. *Journal of Environmental Studies and Sciences*, *1*(1), 44–53.

Chapin III, F. S., Power, M., Pickett, S., Freitag, A., Reynolds, J., Jackson, R. B., Lodge, D., Duke, C., Collins, S., Power, A., & Bartuska, A. (2011b). Earth stewardship: Science for action to sustain the human–earth system. *Ecosphere*, *2*(8), 1–20.

Chapin III, F. S., Weber, E., Bennett, E. M., Biggs, R., van den Bergh, J., Adger, W. N., Crépin, A.-S., Polasky, S., Folke, C., Scheffer, M., Segerson, K., Anderies, J. M., Barrett, S., Cardenas, J., Carpenter, S., Fischer, J., Kautsky, N., Levin, S., Shogren, J., … Zeew, A. (2022). Earth stewardship: Shaping a sustainable future through interacting policy and norm shifts. *Ambio*, *51*(9), 1907–1920.

Chatterjee, E. (2020). The Asian Anthropocene: Electricity and fossil developmentalism. *The Journal of Asian Studies*, *79*(1), 3–24.

Clark, W. C. & Munn, R. E. (Eds.). (1986). *Sustainable development of the biosphere*. Cambridge University Press.

Coen, D. (2016). Big is a thing of the past: Climate change and methodology in the history of ideas. *Journal of the History of Ideas*, *77*(2), 305–321.

Connolly, W. (2013). *The fragility of things: Self-organizing processes, neoliberal fantasies, and democratic activism*. Duke University Press.

Cooper, M. (2011). Complexity theory after the financial crisis. *Journal of Cultural Economy*, *4*(4), 371–385.

Cruikshank, J. (2005). *Do glaciers listen? local knowledge, colonial encounters, and social imagination*. Vancouver: UBC Press.

Curley, A. (2019). 'Our winters' rights': Challenging colonial water laws. *Global Environmental Politics*, *19*(3), 57–76.

Daigle, M. (2018). Resurging through *Kishiichiwan*: The spatial politics of Indigenous water relations. Decolonization: Indigeneity, *Education & Society*, *7*(1), 159–172.

Daston, L. (2014). The naturalistic fallacy is modern. *Isis*, *105*(3), 579–587.

Daston, L., & Galison, P. (2010). *Objectivity*. Princeton University Press.

Davis, H., & Todd, Z. (2017). On the importance of a date, or decolonizing the Anthropocene. *ACME: An International Journal for Critical Geographies*, *16* (4), 761–780.

de la Cadena, M. & Blaser, M. (Eds.). (2018). *A world of many worlds*. Duke University Press.

Dotson, K., & Whyte, K. (2013). Environmental justice, unknowability and unqualified affectability. *Ethics and the Environment*, *18*(2), 55–79.

Dryzek, J., & Pickering, J. (2019). *The politics of the Anthropocene*. Oxford University Press.

Duller, M. (2016). Internationalization of Cold War systems analysis: RAND, IIASA and the institutional reasons for methodological change. *History of the Human Sciences*, *29*(4–5), 172–190.

Elser, J., & Haygarth, P. (2021). *Phosphorus: Past and future*. Oxford University Press.

Falkenmark, M., & Folke, C. (2002). The ethics of socio-ecohydrological catchment management: Toward hydrosolidarity. *Hydrology and Earth System Sciences*, *6*(1), 1–10.

Falkenmark, M., Wang-Erlandsson, L., & Rockström, J. (2019). Understanding of water resilience in the Anthropocene. *Journal of Hydrology X*, *2*, 1–13.

Folke, C. (2003). Freshwater for resilience: A shift in thinking. *Philosophical Transactions of the Royal Society of London B*, *358*, 2027–2036.

Folke, C., Carpenter, S., Walker, B., Scheffer, M., Chapin, T., & Rockström, J. (2010). Resilience thinking: Integrating resilience, adaptability and transformability. *Ecology and Society*, *15*(4). Art. 20, 1–9.

Folke, C., Jansson, A., Rockström, J., Olsson, P., Carpenter, S. R., Chapin, F. S., Crepin, A.-S., Daily, G., Danell, K., Ebbesson, J., Elmqvist, T., Galaz, V.,

Moberg, F., Mans, N., Osterblom, H., Ostrom, E., Persson, A., Peterson, G. D., Polasky, S., … Westley, F. (2011). Reconnecting to the biosphere. *Ambio*, *40*(7), 719–738.

Ghosh, A. (2016). *The great derangement: Climate change and the unthinkable*. Penguin Books.

Gleeson, T., Wang-Erlandsson, L., Zipper, S., Porkka, M., Jaramillo, F., Gerten, D., Fetzer, I., Cornell, S., Piemonteses, L., Gordon, L., Rockström, J., Oki, T., Sivapalan, M., Wada, Y., Brauman, K., Flörke, M., Bierkens, M., Lehner, B., Keys, P., … Famiglietti, J. (2020). The water planetary boundary: Interrogation and revision. *One Earth*, *2*(3), 223–234.

Hamilton, C., Gemenne, F., & Bonneuil, C. (Eds.). (2015). *The Anthropocene and the global environmental crisis: Rethinking modernity in a new epoch*. Routledge.

Hardin, G. (1968). The tragedy of the commons. *Science*, *162*(3859), 1243–1248.

Holling, C. S. (2001). Understanding the complexity of economic, ecological, and social systems. *Ecosystems*, *4*(5), 390–405.

Holling, C. S., & Meffe, G. K. (1996). Command and control and the pathology of natural resource management. *Conservation Biology*, *10*(2), 328–337.

Homer-Dixon, T., Walker, B., Biggs, R., Crepin, A.-S., Folke, C., Lambin, E., Peterson, G. D., Rockström, J., Scheffer, M., Steffen, W., & Troell, M. (2015). Synchronous failure: The emerging causal architecture of global crisis. *Ecology and Society*, *20*(3), 6.

Janssen, M. A., Smith-Heisters, S., Aggarwall, R., & Schoon, M. (2019). 'Tragedy of the commons' as conventional wisdom in sustainability education. *Environmental Education Research*, *25*(11), 1587–1604.

Jenkins, W., Rosa, L., Schmidt, J., Band, L., Beltran-Peña, A., Clarens, A., Doney, S., Emanuel, R., Glassie, A., Quinn, J., Rulli, M. C., Shobe, W., Szeptycki, L., & D'Odorico, P. (2021). Values-based scenarios of water security: Rights to water, rights of waters, and commercial water rights. *BioScience*, *71*(11), 1157–1170.

Karera, A. (2019). Blackness and the pitfalls of Anthropocene ethics. *Critical Philosophy of Race*, *7*(1), 32–56.

Kay, J. (2000). Ecosystems as self-organizing Holarchic open systems: Narratives and the second law of thermodynamics. In S. Jørgensen & F. Müller (Eds.), *Handbook of ecosystem theories and management* (pp. 135–160). Lewis Publishers.

Kimmerer, R. W. (2013). *Braiding sweetgrass: Indigenous wisdom, scientific knowledge and the teachings of plants*. Milkweed Editions.

Kuhn, T. (1996). *The structure of scientific revolutions* (3rd ed.). University of Chicago Press.

Kwa, C. (2005). Local ecologies and global science: Discourses and strategies of the international geosphere–biosphere programme. *Social Studies of Science*, *35*(6), 923–950.

Leach, M., Reyers, B., Bai, X., Brondizio, E., Cook, C., Díaz, S., Espindola, G., Scobie, M., Stafford-Smith, M., & Subramanian, S. (2018). Equity and sustainability in the Anthropocene: A social–ecological systems perspective on their intertwined futures. *Global Sustainability*, *1*, E13. doi: 10.1017/sus.2018.12

Leonard, K., David-Chavez, D., Smiles, D., Jennings, L., Alegado, R. A., Tsinnajinnie, L., Manitowabi, J., Arsenault, R., Begay, R., Kagawa-Viviani, A., Davis, D., van Uitregt, V., Pichette, H., Liboiron, M., Moggridge, B., Carrol, S., Tsosie, R., & Gomez, A. (2023). Water back: A review centring rematriation and Indigenous water research sovereignty. *Water Alternatives*, *16*(2), 374–428.

Lewis, S. L., & Maslin, M. A. (2018). *The human planet: How we created the Anthropocene*. Penguin Books.

Liboiron, M. (2021). Decolonizing geoscience requires more than equity and inclusion. *Nature Geoscience*, *14*, 876–877.

Lövbrand, E., Beck, S., Chilvers, J., Forsyth, T., Hedren, J., Hulme, M., Lidskog, R., & Vasileiadou, E. (2015). Who speaks for the future of the Earth? How critical social science can extend the conversation on the Anthropocene. *Global Environmental Change*, *32*, 211–218.

Lubchenco, J. (1998). Entering the century of the environment: A new social contract for science. *Science*, *279*, 491–497.

Lubchenco, J., Olson, A. M., Brubaker, L., Carpenter, S., Holland, M., Hubbel, S., Levin, S., MacMahon, J., Matson, P., Melillo, J., Mooney, H., Peterson, C., Pulliam, R., Real, L., Regal, P., & Risser, P. (1991). The sustainable biosphere initiative: An ecological research agenda: A report from the ecological society of America. *Ecology*, *72*(2), 371–412.

Lubchenco, J., & Rapley, C. (2020). Our moment of truth: The social contract realized? *Environmental Research Letters*, *15*(11), 110201.

MacKinnon, D., & Derickson, K. D. (2013). From resilience to resourcefulness: A critique of resilience policy and activism. *Progress in Human Geography*, *37*(2), 253–270.

Meché, B. (2022). Black as drought: Arid landscapes and ecologies of encounter across the African diaspora. *Environment and Society*, *13*, 60–77.

Meisch, S. (2019). *I want to tell you a story*: How narrative water ethics contributes to re-theorizing water politics. *Water*, *11*(4), 631.

Midgley, G. (2003). *Systems thinking* (volumes *1–4*). Sage Publishing.

Milly, P. C. D., Betancourt, J., Falkenmark, M., Hirsch, R. M., Kundzewicz, Z. W., Lettenmaier, D. P., & Stouffer, R. J. (2008). Stationarity is dead: Whither water management? *Science*, *319*, 573–574.

Moore, G. E. (1922). *Principia ethica*. Cambridge University Press.

Moore, J. W. (2015). *Capitalism in the web of life: Ecology and the accumulation of capital*. London: Verso.

Nace, R. L. (1980). Hydrology comes of age: Impact of the international hydrological decade. *Eos*, *61*(53), 1241–1242.

Nadasdy, P. (2007). Adaptive co-management and the Gospel of resilience. In D. Armitage, F. Berkes, & N. Doubleday (Eds.), *Adaptive co-management: Collaboration, learning, and multi-level governance* (pp. 208–227). UBC Press.

Norton, B. G. (2005). *Sustainability: A philosophy for adaptive ecosystem management*. University of Chicago Press.

Oppenheimer, M., Oreskes, N., Jamieson, D., Brysse, K., O'Reilly, J., Shindell, M., & Wazeck, M. (2019). *Discerning experts: The practices of scientific assessment for environmental policy*. University of Chicago Press.

Oreskes, N. (2020). What is the social responsibility of climate scientists? *Daedalus*, *149*(4), 33–45.

Osorio, F. B. (2017). Environmental ethics and science: Resilience as a moral boundary. *Journal of Agricultural and Environmental Ethics*, *30*, 121–134.

Park, D., Feng, X., Akiyama, S., Ardivani, M., Avendaño, N., Barina, Z., Bärtschi, B., Belgrano, M., Betancur, J., Bijmoer, R., Boggaerts, A., Cano, A., Danihelka, J., Garg, A., Giblin, D., Gogoi, R., Guggisberg, A., Hyvärinen, M., James, S., … Davis, C. C. (2023). The colonial legacy of herbaria. *Nature Human Behaviour*, *7*, 1059–1068. https://doi.org/10.1038/s41562-023

Pauli, B. J. (2019). *Flint fights back: Environmental justice and democracy in the flint water crisis*. MIT Press.

Peterson, M. (2019). *Pipe dreams: Water and empire in Central Asia's Aral Sea basin*. Cambridge University Press.

Piketty, T. (2017). *Capital in the twenty-first century*. Harvard University Press.

Plummer, R., Baird, J., Farhad, S., & WItkowski, S. (2020). How do biosphere stewards actively shape trajectories of social–ecological change? *Journal of Environmental Management*, *261*, 110139.

Poprocki, K. (2022). On viability: Climate change and the science of possible futures. *Global Environmental Change*, *73*, 102487.

Porter, T. M. (1995). *Trust in numbers: The pursuit of objectivity in science and public life*. Princeton University Press.

Purifoy, D. (2021). The parable of black places. *Transactions of the British Institute of Geographers*, *46*(4), 829–833.

Quine, W. V. O. (1987). "Inderminacy of translation again." *Journal of Philosophy*, *84*(1), 5–10.

Quine, W. V. O. (1960). *Word and object*. Cambridge: MIT Press.

Raja, N., Dunne, E., Matiwane, A., Khan, T., Nätscher, P., Ghilardi, A., & Chattopadhyay, D. (2022). Colonial and global economics distort our understanding of deep-time biodiversity. *Nature Ecology & Evolution*, *6*, 145–154.

Ranganathan, M., & Balazs, C. (2015). Water marginalization at the urban fringe: Environmental justice and urban political ecology across the north-south divide. *Urban Geography*, *36*(3), 403–423.

Reisch, G. A. (2005). *How the Cold War transformed philosophy of science: To the icy slopes of logic*. Cambridge University Press.

Rindzevičiūtė, E. (2016). *The power of systems: How policy sciences opened up the Cold War world*. Cornell University Press.

Ripl, W. (2003). Water: The bloodstream of the biosphere. *Philosophical Transactions of the Royal Society of London B*, *358*, 1921–1934.

https://doi.org/10.1017/sus.2023.13 Published online by Cambridge University Press

Rockström, J., Falkenmark, M., Allan, J. A. T., Folke, C., Gordon, L., Jägerskog, A., Kummu, M., Lannerstad, M., Meybeck, M., Molden, D., Postel, S., Savenije, H. H. G., Svedin, U., Turton, A., & Varis, O. (2014). The unfolding water drama in the Anthropocene: Towards a resilience-based perspective on water for global sustainability. *Ecohydrology: Ecosystems, Land and Water Process Interactions, Ecohydrogeomorphology*, *7*, 1249–1261.

Rodina, L. (2019). Defining 'water resilience': Debates, concepts, approaches, and gaps. *WIREs Water*, *6*(2), e1334.

Rozzi, R., Chapin III, F. S., Callicott, J. B., Pickett, S., Power, M., Armesto, J. J., & May Jr., R. (2015). *Earth stewardship: Linking ecology and ethics in theory and practice*. Springer.

Sankey, H. (1993). Kuhn's changing concept of incommensurability. *The British Journal for the Philosophy of Science*, *44*(4), 759–774.

Savenije, H. H. G., Hoekstra, A. Y., & van der Zaag, P. (2014). Evolving water science in the Anthropocene. *Hydrology and Earth System Sciences*, *18*, 319–332.

Schill, C., Anderies, J. M., Lindahl, T., Folke, C., Polasky, S., Juan Camilo, C., Crépin, A.-S., Janssen, M. A., Norberg, J., & Schlüter, M. (2019). A more dynamic understanding of human behaviour for the Anthropocene. *Nature Sustainability*, *2*, 1075–1082.

Schmidt, J. J. (2017a). *Water: Abundance, scarcity, and security in the age of humanity*. New York University Press.

Schmidt, J. J. (2017b). Social learning in the Anthropocene: Novel challenges, shadow networks, and ethical practices. *Journal of Environmental Management*, *193*, 373–380.

Schmidt, J. J. (2022). Of kin and system: Rights of nature and the UN search for Earth jurisprudence. *Transactions of the Institute of British Geographers*, *47*(3), 820–834.

Schmidt, J. J. (2023). From integration to intersectionality: A review of water ethics. *Water Alternatives*, *16*(2), 321–345.

Schmidt, J. J., & Matthews, N. (2018). From state to system: Financialization and the water–energy–food–climate nexus. *Geoforum; Journal of Physical, Human, and Regional Geosciences*, *91*, 151–159.

Scott, C. (1996). Science for the West, myth for the rest? The case of James Bay Cree knowledge production. In L. Nader (Ed.), *Naked science: Anthropological inquiry into boundaries, power and knowledge* (pp. 69–86). Routledge.

Seitzinger, S., Gaffney, O., Brasseur, G., Broadgate, W., Ciais, P., Claassen, M., Erisman, J., Kiefer, T., Lancelot, C., Monks, P., Smyth, K., Syvitski, J., & Uematsu, M. (2015). International geosphere–biosphere programme and Earth system science: Three decades of co-evolution. *Anthropocene*, *12*, 3–16.

Seo, K.-W., Ryu, D., Eom, J., Jeon, T., Kim, J.-S., Youm, K., Chen, J., & Wilson, C. R. (2023). Drift of Earth's pole confirms groundwater depletion as a significant contributor to global sea level rise 1993–2010. *Geophysical Research Letters*, *50*(12), e2023GL103509.

Sharp, H. (2020). Not all humans: Radical criticism of the Anthropocene narrative. *Environmental Philosophy*, *17*(1), 143–158.

Siskin, C. (2016). *System: The shaping of modern knowledge*. MIT Press.

Sneddon, C. (2015). *Concrete revolution: Large dams, Cold War geopolitics, and the U.S. Bureau of reclamation*. University of Chicago Press.

Steffen, W., Persson, A., Deutsch, L., Zalasiewicz, J., Williams, M., Richardson, K., Crumley, C., Crutzen, P., Folke, C., Gordon, L., Molina, M., Ramanathan, V., Rockström, J., Scheffer, M., Schellnhuber, H., & Svedin, U. (2011). The Anthropocene: From global change to planetary stewardship. *Ambio*, *40*, 739–761.

Steffen, W., Rockström, J., Richardson, K., Lenton, T., Folke, C., Liverman, D., Summerhayes, C., Barnosky, A., Cornell, S., Crucifix, M., Donges, J., Fetzer, I., Lade, S., Scheffer, M., Winkelmann, R., & Schellnhuber, H. J. (2018). Trajectories of the Earth system in the Anthropocene. *Proceedings of the National Academy of Sciences*, *115*(33), 8252–8259.

Stengers, I. (2005). Introductory notes on an ecology of practices. *Cultural Studies Review*, *11*(1), 183–196.

Stengers, I. (2010). Including nonhumans in political theory: Opening Pandora's box? In B. Braun & S. J. Whatmore (Eds.), *Political matter: Technoscience, democracy, and public life* (pp. 3–33). University of Minnesota Press.

Stengers, I. (2011). Comparison as a matter of concern. *Common Knowledge*, *17*(1), 48–63.

Stoll, M. (2015). *Inherit the holy mountain: Religion and the rise of American environmentalism*. Oxford University Press.

Teaiwa, K. M. (2014). *Consuming Ocean Island: Stories of people and phosphate from Banaba*. Indiana University Press.

Todd, Z. (2017). Fish, kin and hope: Tending to water violations in amiskwaciwâskahikan and Treaty Six territory. *Afterall*, *43*(1), 103–107.

Tuana, N. (2019). Climate apartheid: The forgetting of race in the Anthropocene. *Critical Philosophy of Race*, *7*(1), 11–31.

Uhrqvist, O., & Lövbrand, E. (2014). Rendering global change problematic: The constitutive effects of Earth system research in the IGBP and the IHDP. *Environmental Politics*, *23*(2), 339–356.

Vörösmarty, C. J., Meybeck, M., & Pastore, C. L. (2015). Impair-then-repair: A brief history & global-scale hypothesis regarding human–water interactions in the Anthropocene. *Daedalus*, *144*(3), 94–109.

Vörösmarty, C. J., Pahl-Wostl, C., Bunn, S. E., & Lawford, R. (2013). Global water, the Anthropocene and the transformation of a science. *Current Opinion in Environmental Sustainability*, *5*(6), 539–550.

Walker, J., & Cooper, M. (2011). Genealogies of resilience: From systems ecology to the political economy of crisis adaptation. *Security Dialogue*, *42*(2), 143–160.

Wang-Erlandsson, L., Tobian, A., van der Ent, R., Fetzer, I., Wierik, S., Porkka, M., Staal, A., Jaramillo, F., Dahlmann, H., Singh, C., Greve, P., Gerten, D., Keys, P. W., Gleeson, T., Cornell, S., Steffen, W., Bai, X., & Rockström, J. (2022). A planetary boundary for green water. *Nature Reviews Earth & Environment*, *3*, 380–392.

Watt-Cloutier, S. (2018). *The right to be cold: One woman's fight to protect the Arctic and save the planet from climate change*. University of Minnesota Press.

West, S., Haider, L. J., Masterson, V., Enqvist, J., Svedin, U., & Tengö, M. (2018). Stewardship, care and relational values. *Current Opinion in Environmental Sustainability*, *35*, 30–38.

Williams, B. (1985). *Ethics and the limits of philosophy*. Harvard University Press.

Wilson, N. J., & Inkster, J. (2018). Respecting water: Indigenous water governance, ontologies, and the politics of kinship on the ground. *Environment and Planning E: Nature and Space*, *1*(4), 516–538.

Wolfe, A. (2018). *Freedom's laboratory: The Cold War struggle for the soul of science*. John Hopkins University Press.

Worster, D. (1994). *Nature's economy: A history of ecological ideas, second edition*. Cambridge: Cambridge University Press.

Yates, J., Harris, L., & Wilson, N. J. (2017). Multiple ontologies of water: Politics, conflict and implications for governance. *Environment and Planning D: Society and Space*, *35*(5), 797–815.

https://doi.org/10.1017/sus.2023.13 Published online by Cambridge University Press